

Suwa Seikosha's Television Watch

by James A. Mahaffey (GA)

Shortly after the watch was invented, there was a movement to add personal entertainment activities to the watch's practical functions. These embellishments were designed strictly to amuse the owner while retaining a timekeeping function. At first automata were added, or little animated figures making small, repetitive motions, such as swinging a hammer or waving a handkerchief. Next, subminiature music boxes were added to play upon demand or upon the hour, sometimes combined with an automata scene.

There was a limit to how much entertainment would fit in a pocket watch, and the introduction of the wristwatch further limited the amount of space available for non-timing machinery. Then, in the 1970s, fully electronic watch mechanisms became practical manufactured items, and the possibilities for personal entertainment seemed endless. AM radios, FM radios, music synthesizers, and arcade games have all been incorporated into electronic watches, as well as many practical auxiliary functions ranging from digital calculators to global positioning system receivers. The ingenuity displayed in the miniaturization of devices to be included in personal timepieces is impressive, but nothing in amusement systems may quite surpass the bold design of Suwa Seikosha, who put the world's smallest direct-view television screen in a wristwatch.

Suwa Seikosha was one of several manufacturing companies in the Seiko Group, which evolved from K. Hattori & Company, an import/export trading company specializing in clocks and watches, established in 1881. In 1964, Suwa Seikosha established a solid reputation in the clock business by building the automatic timers for the Tokyo Olympic Games. In 1969, the company perfected the world's first quartz watch, and in 1973 introduced the liquid crystal display (LCD) as a time read-out on a wristwatch.



Figure 1. The Seiko television wristwatch. If you're old enough to recognize the RCA "Indian head" test pattern, then you probably need glasses to see the screen.

On June 16, 1982, Suwa Seikosha, in the Hotel Okura in Tokyo, announced to the world the result of years of development and several hundred million yen—the television watch. Into a rectangular metal case, 76 by 143 by 18 millimeters and weighing 190 grams, they had integrated a conventional LCD quartz watch and a 1.2-inch (diagonal) television monitor. The receiver fit in a pocket-sized box (74.5 by 125 by 19 millimeters, 140 grams), and conducted video signals to the monitor through a flexible 6-conductor cable. The user was to wear headphones which connected to the receiver box and served as an antenna. The electronics press was enchanted by the tiny TV picture, but was a bit skeptical that this watch would sell enough units to justify the estimated two trillion yen (about 10 million dollars) necessary to tool up for production. The United States was the targeted market, so the receiver was built to decode National Television Standards Committee (NTSC) signals, and the retail price was set at \$495.

There were still problems to be solved. The display looked dim, with only 20 to 30 percent contrast using 10 levels of gray, and the refresh rate was too low, causing rapidly moving pictures to smear. The linear refresh-rate was 50 to 100 millimeters per second, and it would have to be increased significantly before production. Shelf-life of the television screen module was estimated to be seven years. The design was protected by 10 basic patents and 150 related patents, and there were still these kinks to be worked out.

Although the LCD was a mature technology by this time, the process of ultra-miniaturized, animated display was on the frontier. The usual nematic LCD technology was too slow for this application, by orders of magnitude. For this specific product Suwa Seikosha developed a field effect (FE) very large scale integrated (VLSI) circuit having 31,920 pixels, arranged in a 150

by 210 element matrix, on a single silicon wafer 30 by 22 by 1.4 millimeters. On this chip was sufficient circuitry to decode an analog NTSC signal and address the digital LCD array, given a separate frame-timing signal. Refresh rate problems were resolved, and production began at a special factory in Fujimi, Japan, with watch assembly in the Shimauchi Precision Instruments factory in Matsumoto.

Timing of the announcement was critical, as Sir Clive Sinclair of Sinclair Research Ltd. was leaking information about his impending wristwatch TV to be offered in the near future. Production watches went on sale in early 1983, initially with one watch given to each Seiko dealer. The earliest models, designated T001-5000, were sold in a silver colored cardboard box, with a silver colored leather case to protect the receiver module. A mechanically delicate pair of stereo headphones was included, and the 6-conductor connecting cord was packed separately. Two AA-cells were provided as an initial power source. The only optional accessory was an AC power adapter, part no. TD02. The earliest example of a T001-5000 I have found is serial no. 200646.

The initial production watch differed externally from the prototype watch in a few cosmetic details. The screen and watch display in the production model had a black frame surrounding a satin chrome frame, with watch button functions denoted in the black area, where the prototype was strictly cased in satin chrome. The cable connector, which had to be a robust design to survive long in the hands of the consumer, was hidden behind a satin chrome shroud in the prototype, but this was reduced to a black plastic block in the initial production model.

Sales were disappointing, and production lasted only about a year. The total number of watches produced is hard to determine, with estimates ranging from 2,000 to 20,000; non-consecutive serial numbers were used and provide no help in determining production quantities. The company had hoped to build 13,000 but may have been unable to meet this quota. A limiting factor from a manufacturing standpoint was the

problems encountered in mass-producing the TV-monitor chip. Although the U.S. market did not live up to Seiko's expectations, the TV watch did infiltrate popular culture via Hollywood, appearing in the movies *Dragnet*, *Wall Street* and *Octopussy*.

Although there were plans to use this technology as a springboard to making a wristwatch computer display terminal, introduction of such a device would wait for another decade. Suwa Seikosha and the Epson Corporation merged in 1985,

forming the Seiko Epson Corporation. Sinclair's TV watch never appeared.

How the TV Watch Performs

The initial production model is rare, and most examples to be found are the model T001-5019. A specimen is shown in Figure 1, and Figure 2 shows the watch in relation to its receiver module. This model closely resembles the prototype, except that the name "Suwa Seikosha" on the prototype was changed to "Seiko," and the legend "TELEVISION WATCH" across the top was deleted from the production model. The cable connector atop the case is bolstered on each



Figure 2. The TV watch with its receiver unit, connected by a cable. The cable runs under your sleeve, with the receiver in an inside jacket pocket—a handy feature for church services, weddings, and other enforced events.

side by metal brackets, cast en-bloc with the case. This watch was sold in a gold colored cardboard box, with a sewn black leather case to hold the receiver.

The watch portion of this system is a conventional quartz watch with an LCD array, with time (12 and 24-hour), alarm, date, and stopwatch functions, controlled by three push-buttons.

The "liquid video display" (LVD) operates passively, in that there is no illumination behind the screen, and viewing light is incident. There are two advantages to this design: it saves a great deal of power, and the screen can be seen in bright sunlight that would completely wash out a conventional TV picture. The disadvantage is that the image is rather dim. The engineering problem that leads to this lack of brightness is that 150 conductors must run over the top of the display to supply the vertical address to pixels, and these printed "wires" block the light. This is not noticeable in most LCD panels because so few picture elements are used, but in this case the panel is crowded with unusually dense pixels.

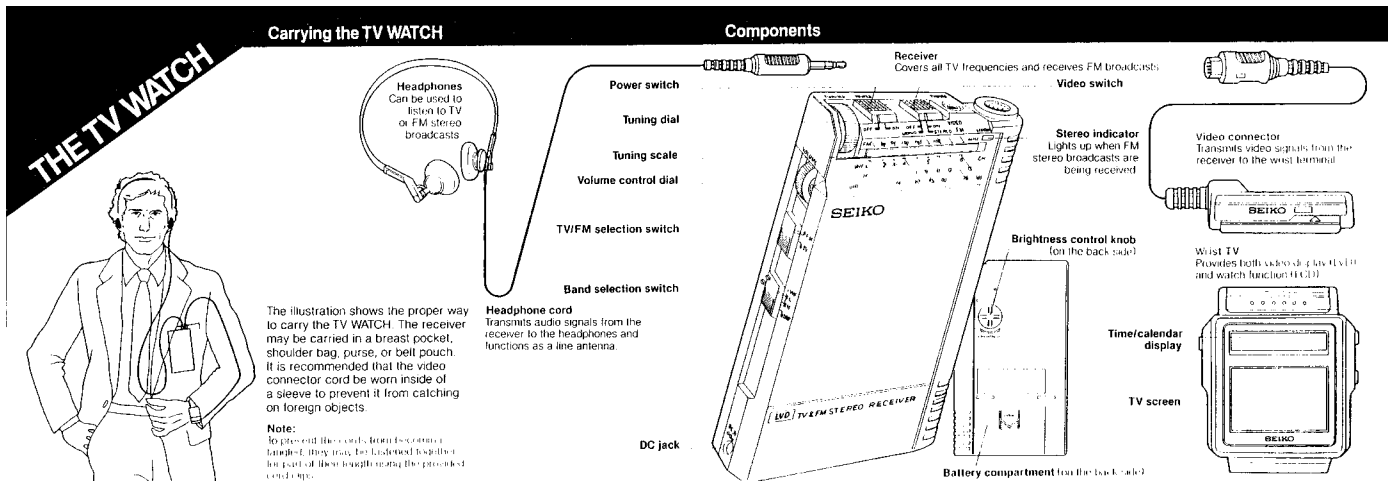


Figure 3. A page from the TV watch user's manual.

Once you get used to the dimness of the television image, the sharpness and the apparent richness of detail are startling. You can easily read numbers and written words flashed briefly across the screen, provided your eyes can focus close enough. The refresh rate of the screen, which was a major worry for the engineers who worked on the television watch, is not a noticeable problem. If there is enough light to read the time on the watch, then there is enough light to see the TV screen, and it works well in the brightest sunlight. There is no image distortion, "pincushion" effect, or problems of vertical hold, because the imaging elements are in fixed positions on a monolithic silicon substrate, and picture-timing is provided by a master crystal-controlled oscillator, giving a precise 29.97 frames per second. Figure 3 is taken from the owner's manual, showing the working features of this unusual watch.

Contrary to some rumors, there is no special "antenna wire" in the headphone cable. The television signal is derived from the shield on the cable, and any eighth-inch stereo headphone or 8-ohm single-channel earphone will work. The television receiver is able to stay locked on a video signal under the unfavorable condition of having a flexible antenna constantly changing orientation. The station selector is an analog adjustment, by thumb-wheel, over three switched ranges. By using a mechanical station selector, rather than a digital electronic stepping device, the Seiko design is able to withstand momentary signal loss without loss of channel lock. Other contemporary subminiature television designs, such as the Casio TV-21, used the less bulky, less expensive digital tuner and can suffer station loss. Motion of the tuning wheel is conducted to the tuning potentiometer by an internal ring gear, through one idler pinion. A worm-and-nut moves the tuning cursor against a linear scale of the three television bands (low VHF, high VHF, and UHF) and an FM radio band.

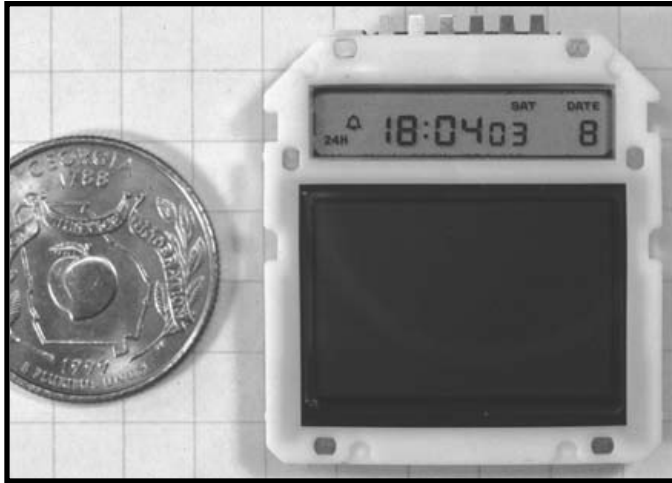
On the radio frequency spectrum, FM radio lies between channel 6 and channel 7 in the television band, squeezed into only 16 megahertz of band width. The TV watch receiver exploits the fact that it already has an FM sound-tuner for the television function, and it simply tunes sound on the FM radio band with the picture blanked, giving the watch an extra function. Performance of the radio function is disappointing, probably because the TV tuner is built to extract as much energy as possible from a TV signal using an unusually wide intermediate frequency (IF) amplifier stage. Closely spaced FM stations, therefore, tend to bleed into one another.

TV Watch Service Procedures

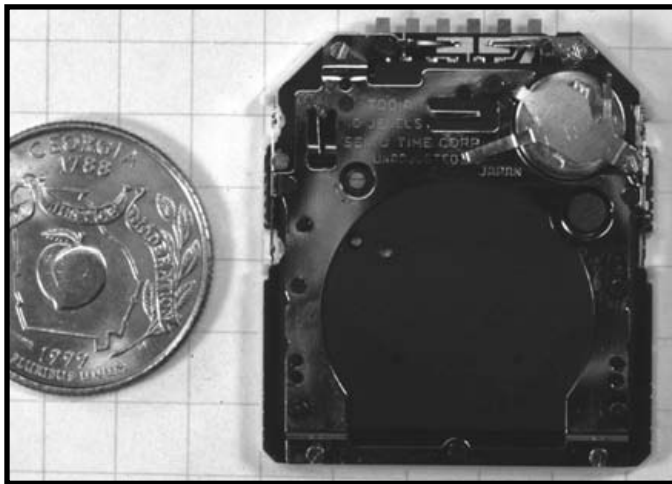
The engineering estimate of a seven-year life for the TV-screen module was pessimistic. Seventeen years later, most TV watches are still working and are still just as dim as they were the day they were bought. There is a report of a TV watch that has operated 12 hours a day since 1983 in the window of a jewelry store in Singapore, as its box and owner's manual have bleached in the sunlight.

Replacement parts are no longer available for this watch, but fortunately many of its perishable components are generic and are still for sale. The watch chassis is shown in Figure 4 (front) and Figure 5 (back). The watch battery is a silver oxide Maxell SR920W, and it has no connection with the television function. Note the six gold-plated fingers at the top of the chassis. These connect, by simple tension, to the flush-mounted, weatherproof pins of the television connector at the top of the watch. The back presses on, and although there is no implied water resistance, it is fitted with a rubber seal.

Correctable problems occur in the receiver module, shown partially dismantled in Figure 6. Although this unit is about the size of a pocket radio, it is built with



Figures 4 and 5. Above, front of watch mechanism. Below, the back.



more watchmaking influence than with pocket radio design practices, as it is built in layers, and it is put together with 1mm screws. A 2mm Phillips screwdriver will take it apart, starting with two flush-mounted screws on the bottom, holding the metal front cover. The cover then slides off. The side cover, having the TV cable socket, comes off next, with one screw on the bottom. It is connected to the electronic chassis by way of a thin mylar ribbon cable, terminated in gold-plated spears. Be especially careful with this ribbon, as it can develop hairline cracks if overly exercised. Two screws in front hold the metal top cover, which will lift off with switch knobs attached. The two plastic covers for the electronic section are held together with long 1mm Phillips screws, and some finesse is necessary to separate the mechanism from the backplate. Two layers of printed wiring boards are held together by two mylar ribbon bridges. If necessary, the two boards may be separated using 0.03-inch solder wick and a 25-watt iron. A 3-volt power supply attached to the remaining battery contacts, or through the external power jack, will run the television for bench work.

There are four adjustments for the receiver, and the maintenance adjustment points are shown in Figure 7. The adjustment point shown on the left side of the picture is a 260-degree potentiometer, and it changes the tuner offset, for the purpose of lining up the tuning cursor with the channel numbers. The point in the middle is the video gain, or contrast, and it is also a 260-degree potentiometer. Both of these adjustment points are accessible with the metal front cover off, through holes in the plastic frontplate. Use a 2mm bladed screwdriver. The video offset, or brightness, is adjustable by hand, with a thumb-operated knob on the back of the chassis. The third adjustment point shown in the photo, on the right, is the power converter frequency, or converted voltage level. Although a special tool is used for this adjustment, this subminiature potentiometer can be turned easily with a 1mm bladed screwdriver.

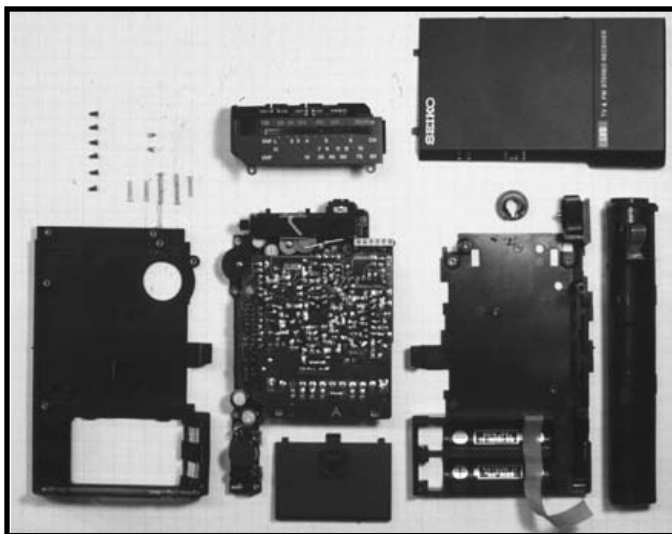
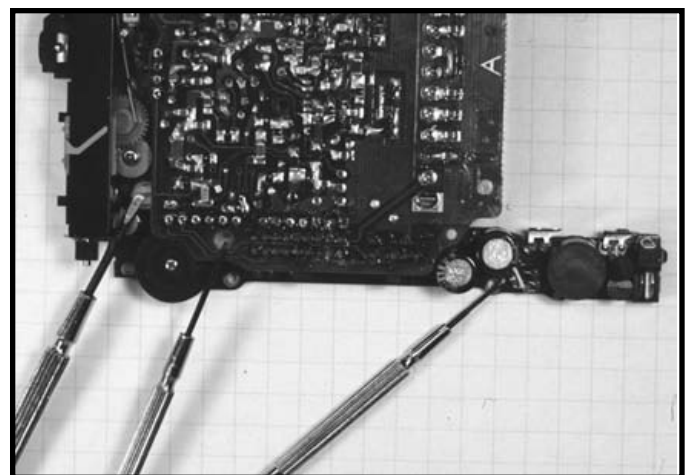


Figure 6, above. The television receiver, broken down. **Figure 7, right.** Maintenance adjustment points at the ends of the screwdrivers. On the left is the tuning offset, middle is the contrast, and right is the power level.



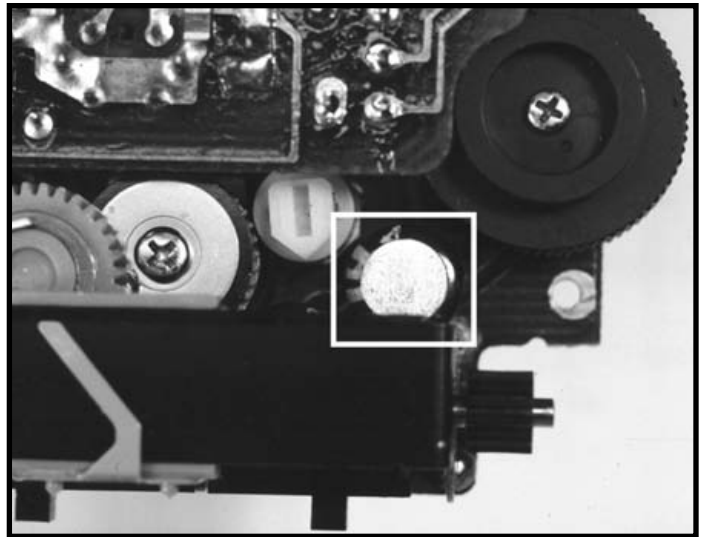
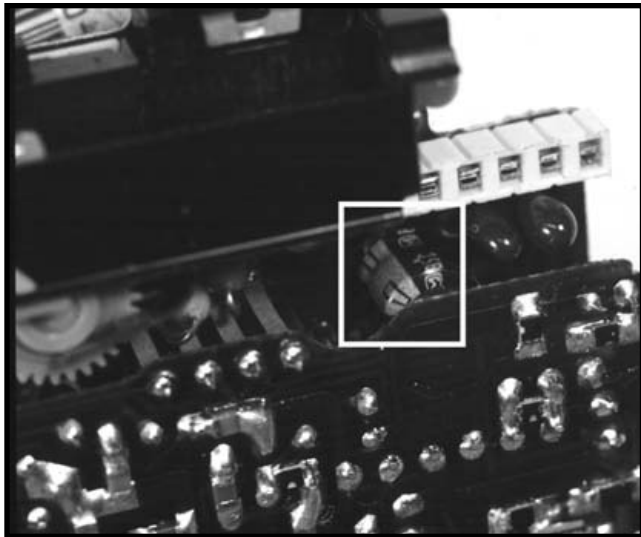


Figure 8, left. The top front of the electronics chassis, showing an electrolytic capacitor position (in white box) at center frame. Although it seems trapped between the circuit boards, it is possible to replace this capacitor without separating the boards. **Figure 9, right.** Another tight capacitor location (in white box), nested between the volume control, the contrast potentiometer, and the tuner slide.

Components most likely to fail due to age in the receiver module are the subminiature electrolytic capacitors. There are five critical capacitors. Two are 47 microfarads, and three are 100 microfarads. All five have a breakdown voltage of 6.3 volts, and their positions in the electronic chassis are shown in Figures 8, 9, and 10. A shorted or opened electrolytic capacitor affects one of three critical DC voltages, either dropping it slightly or allowing AC contamination. The slightest skewing of a DC voltage to the TV monitor will either completely blank the screen or scramble the image into roughly horizontal bars. When diagnosing voltage problems, check the battery connection paddles for corrosion, and check the soldered bases of these paddles for hairline cracks.

Failed capacitors can be found by visual inspection with a loupe. As the caustic electrolyte leaks out it combines with copper in the wiring to form a waxy substance, bright green in color. The slightest hint of green at the base of a capacitor indicates failure. The replacements are special, low-profile, radial-lead units built by Panasonic, called "KS-Series." The height of a KS capacitor is only 5mm, and they are built to fit in the very close quarters. Although it requires careful work with tweezers, it is possible to replace all electrolytic capacitors without separating the two receiver cir-



Figure 10. Side view of the electronics chassis, showing another capacitive electrolytic capacitor (in white box). The metal structure on the right encloses the TV tuner, shielding it from electromagnetic interference.

cuit boards. Unsolder the failed units using 0.03-inch solder wick. The KS-Series capacitors are available in unit quantities from Digi-Key, 701 Brooke Ave. South, Thief River Falls, MN 56701-0677, 1-800-344-4539.

A convenient port for measuring the three critical voltages and seeing the television signals is the end of the signal cord, at the connector that fits on the watch. There are six gold-plated contacts on the connector, plus one gold contact in the anchor point opposite the cord, used for chassis ground. Numbering the line of contacts beginning with the one nearest the cord, the signals are as follows:

- 1) 8.9 volts DC.
- 2) 13.2 volts DC.
- 3) 4.1 volts DC.
- 4) Ground.
- 5) Low-going 5-volt pulses, spaced at 60 microseconds (frame-rate pulse).
- 6) 8.0 volts DC, with an NTSC television signal superimposed on top, 1.5 volts in height, repeating every 60 microseconds. The 8.0 volts is the brightness level, and it may vary widely among different watches and with different settings on the receiver back.

The DC voltages can be read with a volt-ohm meter. A five percent deviation up or down will scramble the TV image, and the three voltages can be adjusted in

concert by turning the converted voltage level control, as mentioned above. A single voltage dropout indicates a possible electrolytic capacitor failure, and these values should be confirmed on an oscilloscope, as there should be a zero ripple component. In one case, I found the voltage on pin 2 absent, and I spent an interesting time tracing it through both circuit boards until I lost it as the copper trace disappeared under a tiny blob of glue. The glue was used to immobilize an open coil. Under the glue blob I found that the very thin copper trace had corroded through, probably due to a microscopic ball of moisture getting trapped just as the glue was applied. I bridged the gap with an exceedingly thin strand of copper wire.

One slight but notable change occurred in the case design of the T001-5019 watch, as shown in Figure 11. There is a slight depression on either side of the cable socket, intended to secure the cable plug so it won't pop off. Fixed steel balls fall into the depressions on oppo-



Figure 11. Two TV watch cases. The top case, SN330135, has a well formed dimple for the signal connector, while the bottom case, SN351357, has a dimple that is too shallow.

site sides of the socket, under tension from the structure of the plug. For some reason the left depression was made less deep in late watches, and the cable snaps off too easily. This depression can be modified with a 1.5mm drill or end-mill. Correct depth is 0.5mm.

References

- ¹ "Armbanduhr mit Fernseher," *Das Electron International*, No. 8-9, pp.221-2, 1982.
- ² "Wrist Watching! (Wrist-watch TV)," *Middle East Electronics*, Vol. 7, No. 3, March 1984, p.41.
- ³ Seiko TV Watch T001/Instruction Manual, 1983.

About the Author

James A. Mahaffey has a BS in Physics, an MS and a PhD in Nuclear Engineering, and is Director of Advanced Research at Nanoventions in Roswell, GA. He is contributing editor to the Mercedes Benz Club of America magazine, *The Star*, and he wears a Breitling Navitimer 806 every day.

IN MEMORIAM

Donald G. Lance (1915-2000) • FNAWCC 1206

Donald G. Lance, a member of NAWCC and Great Lakes Chapter 6 since 1952, died September 17, 2000. He was extremely proud of his NAWCC membership and ordered his 45-year pin the first time it became available. At one time he had more than 200 clocks. His field of interest was primarily American wood movement clocks, and he became an authority on them and an expert restorer of both movements and cases. He presented several chapter programs on this subject. He boasted that he could take apart and put back together a wood movement blindfolded, and had been seen doing it.

He served the Great Lakes chapter as treasurer, as NAWCC Annual Meeting Reception Chairman, and as president in 1961-63. He also served on the national membership committee. He taught classes on antique clock repair at Macomb Community College, and as a result of his sharing his extensive knowledge and encouraging several people to join the NAWCC, he was named a Fellow in 1971 and was given the Great Lakes Chapter Outstanding Member Award by President Owen Burt in 1995.

Don was a great believer in reading. He owned almost every clock book ever published. Even in his 85th year, he

was still in correspondence with other NAWCC members, researching clock problems. He also believed in having fun in life, and when he conducted the chapter auctions for many years he made them hilarious events, as well as profitable for the chapter.

Don loved antique clocks, but he loved the collectors of antique clocks even more. He had friends from many walks of life, but among his most treasured friendships were those with several special fellow clock collectors. He always had great praise for the organization which brought them together—the National Association of Watch and Clock Collectors.

One of his favorite poems, author unknown, was:

"The clock of life is wound but once
And no one has the power
To tell just when the hands will stop
At late or early hour.
Now is the only time you own
Live, love, toil with a will.
Place no faith in tomorrow for
The clock may then be still."

Mrs. Lois Lance